
TIME—RECKONING

FOR THE

Twenty-first Century,

BY

SANFORD FLEMING,

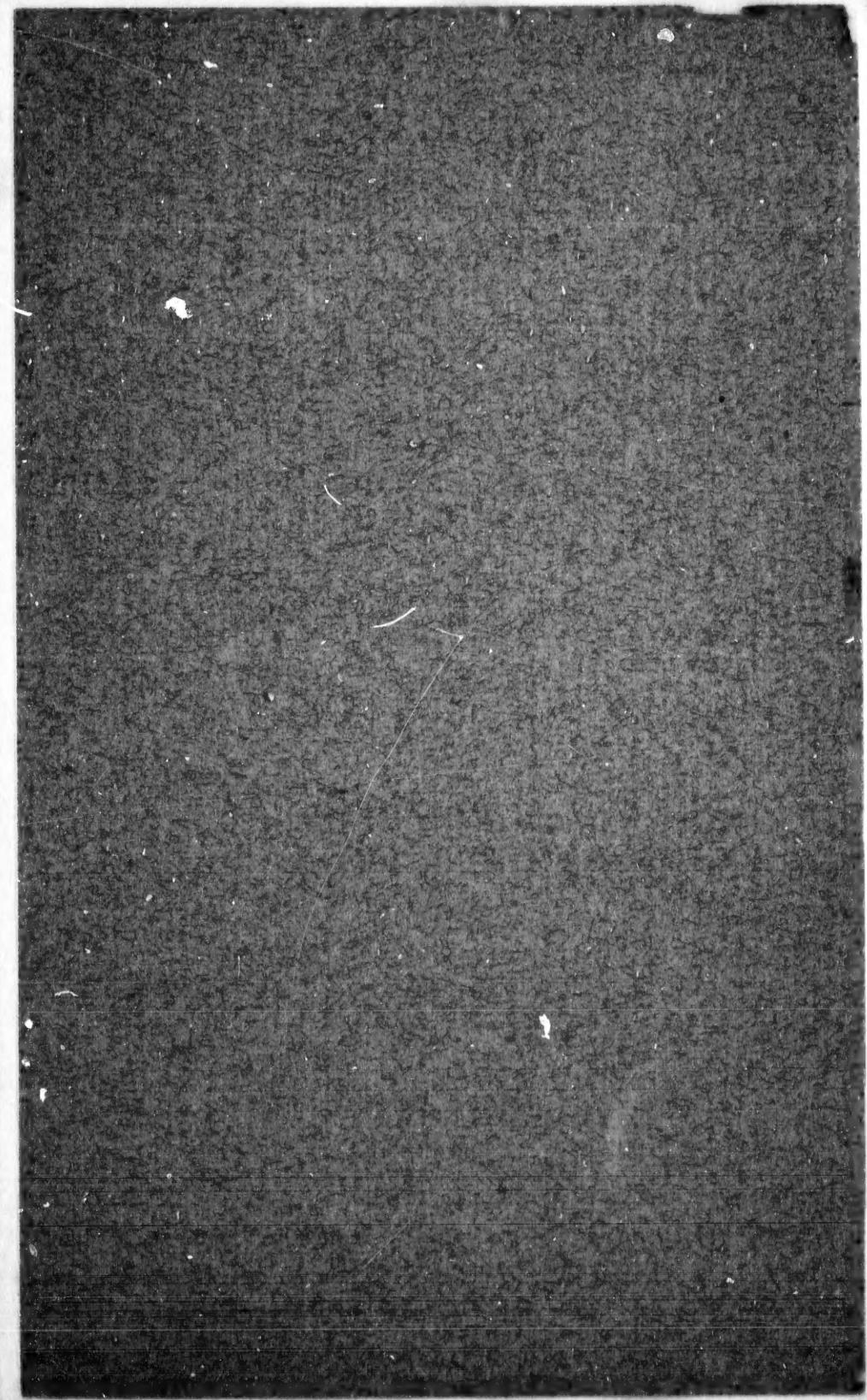
C. M. G., LL. D., C. E., ETC.

From the SMITHSONIAN REPORT For 1886.

WASHINGTON.

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TIME-RECKONING FOR THE TWENTIETH CENTURY.

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During the early historical ages much chronological confusion prevailed, and it is largely owing to this cause that the annals of the centuries which preceded the Christian era are involved in obscurity. The attempt to end this general disorder was made by Julius Cæsar, who established regulations with respect to the divisions of time and the mode of reckoning to be followed. The Julian Calendar was introduced forty-six years before Christ. It continued unchanged until the sixteenth century. In 1582 recognition was obtained of the errors and defects which the circumstances of the period had made manifest and which demanded correction. Pope Gregory XIII accordingly directed the reformation of the calendar and established new rules of intercalation. These two epochs are certainly the most important in the history of our chronology.

Three centuries have passed since the reform of Pope Gregory. New continents have been opened to civilization and immense regions then wholly unknown to Europe have been peopled by races busied in commerce and skilled in the arts, and characterized by unwearied energy and determination. In these three hundred years a marvellous succession of inventions bearing upon human activity and progress has been introduced, and the character of nearly every requirement of life has undergone change. The discoveries and inventions which have marked this period have produced new conditions of society; and our minds have received an impulse which leads to investigation wherever need of improvement appears to be demanded. It is within the last half century more especially that the bounds of human knowledge have been so wonderfully extended; perhaps in the whole world's annals no fifty years have witnessed such a marvellous revolution. The triumphs of applied science in facilitating intercourse between men and nations have given an extraordinary impulse to general progress, but in so doing they have developed imperfections in our system of time-notation which previously were unknown, and it is no longer possible to escape the conviction that we have reached a stage when further reform is demanded as a requirement of our condition. The necessity for a reform in time-reckoning is recognized by the highest authority, and has obtained a hold of public opinion. The President of the United States, General Arthur, at the request of Congress, authoritatively took proceedings to bring the subject prominently to the attention of the world. After prolonged diplomatic correspondence with the Governments of

foreign powers, he invited delegates from all nations to a scientific conference at Washington in which the subject should be fully considered.

The conference met in the autumn of 1884. Twenty-five nationalities were represented. The proceedings extended over the month of October, and they resulted in the almost unanimous adoption of seven resolutions bearing upon time-reckoning.

As no records can be in accord unless a common starting point be agreed upon from which computations are to be made, the first resolutions had reference to the determination of an initial meridian. The meridian passing through Greenwich was selected.

In the fourth and fifth resolutions the conference laid down the following important principles:

IV. "That the conference proposes the adoption of a universal day for all purposes for which it may be found convenient and which shall not interfere with the use of local or other standard time where desirable."

V. "That the universal day is to be a mean solar day; is to begin for all the world at the moment of mean midnight of the initial meridian, coinciding with the civil day and date of that meridian, and is to be counted from zero to twenty-four hours."

The opening of the national Congress at Washington shortly followed the international conference. The President regarded the importance of the proceedings to be such as to call for special mention of them in his annual message. General Arthur thus expressed himself on the subject: "The conference concluded its labors on the 1st of November, having with substantial unanimity agreed upon the meridian of Greenwich as the starting point whence longitude is to be computed through one hundred and eighty degrees eastward and westward, and upon the adoption, for all purposes for which it may be found convenient, of a universal day, which shall begin at midnight on the initial meridian and whose hours shall be counted from zero up to twenty-four."

There was no exaggerated importance in these allusions, for the conclusions of the conference are productive of most important results. They make provision for terminating all ambiguity in hours and dates and for establishing throughout the world, free from national susceptibility and caprice, perfect uniformity in reckoning time. Some years may elapse before the new notation becomes the one recognized mode of reckoning; but when it shall have been generally accepted in the practice of daily life, it is calculated to sweep away the difficulties now experienced, and it will add greatly to the general convenience of civilized man.

One of the first practical efforts to direct public attention to the rapidly growing necessity for a comprehensive reform in time-reckoning can be found in a paper published in the *Transactions of the Canadian Institute*, Toronto, for the session of 1878-79.* This paper adduces in

* Time-reckoning; and the selection of a prime meridian to be common to all nations.
By Sandford Fleming.

support of its argument many pertinent facts, and points out that the gigantic systems of railways and telegraphs which in modern times have been established in both continents have developed social and commercial conditions which never previously existed. These conditions have so affected the relations of time and distance as to establish the fact that our inherited system of notation is defective; that it is inconvenient to men of business; that it produces confusion and frequently results in loss of life, and leads to other difficulties; that under the circumstances which have followed the substitution of steam for animals as a motive power, the ancient usages as retained in our notation of hours and dates are generally inappropriate. Moreover, the use of the telegraph in our daily lives practically subjects the whole surface of the globe to the observation of civilized communities in each individual locality. It leaves no interval of time between widely separated places proportionate to their distances apart. It practically brings into close contact the opposite sides of the earth where daylight and darkness prevail at the same period. By this agency noon, midnight, sunrise, sunset, and the whole range of intermediate gradations of the day, are all observed and recognized at the same moment. Thus in matters out of the domain of local importance confusion is developed and all count of time is thrown into multiplied disorder.

Again, under the usages now observed, a day is assumed to begin twelve hours before—and end twelve hours after—the sun passes the meridian of any place. As the globe is constantly revolving on its axis, a fresh meridian is every moment coming under the sun; as a consequence a day is always beginning somewhere and always ending somewhere. Each meridian around the circumference of the sphere has its own day, and therefore it results that there are, during every diurnal revolution of the earth, an infinite number of local days all beginning within a space of twenty-four hours and each continuing twenty-four hours. These days overlap each other, but they are as perfectly distinct as they are infinite in number. While a day is nominally twenty-four hours in length, as a matter of fact forty-eight hours elapse between the first beginning and the last ending of every week day. Taking the whole globe into our view, Sunday actually commences in the middle of Saturday and lasts until the middle of Monday. Again, Saturday runs into the middle of Sunday, while Monday begins twenty-four hours before Sunday comes to an end and continues twenty-four hours after Tuesday commences. Similarly for all the days of the week, as time is now reckoned. Except those on the same meridian, there are no simultaneous days on the earth's surface, and as the different days are always in the various stages of advancement, discrepancies and errors must necessarily result in assigning the precise period when an event takes place. The telegraph may give the exact local time of an occurrence, but the time so given must be in disagreement with local time on every other meridian around the globe. An event occurring on any one day

may on the instant be announced in a locality where the time is that of the previous day, and in another locality where the time is that of the following day. About the period when the month or year passes into another month or year an occurrence may actually take place, according to our present system of reckoning, in two different months or in two different years; indeed, there can be no certainty whatever with regard to time, unless the precise geographical position be specified as an essential fact in connection with the event described. Under these circumstances it must be conceded that our present system of notation is most defective, certainly it is unscientific, and possesses every element of confusion; it produces a degree of ambiguity which, as railways and telegraphs become greatly multiplied, will lead to complications in social and commercial affairs, to errors in chronology, to litigation in connection with succession to property, insurance, contracts, and other matters; and, in view of individual and general relationships, it will undoubtedly act as a clog to the business of life and prove an increasing hindrance to human intercourse.

The problem to be mastered is to put an end to this confusion. In order to do so, it is important that we should endeavor to form correct ideas of time and its attributes.

According to the ordinary usages which we follow, the time of any particular locality depends upon its position on the earth's surface; in other words, upon its longitude. The principle followed is that there is a separate time on every meridian around the circumference of the globe. Let us carry this theory to its logical conclusion. Take, by way of example, a hundred or a thousand meridians, each with a distinct and separate time. It will be conceded that what is true of one point on a meridian must be true of every point. A meridian line runs due north and south on the earth's surface from pole to pole; hence it follows that at the point where every meridian must converge we have the time of every meridian. That is to say, at the earth's pole, a point common to every meridian, there are a hundred or a thousand different notations of time, each distinct and separate. The extreme absurdity of this hypothesis establishes beyond question that the premises are false; and it is in no way surprising that confusion and difficulty result from a system such as we possess, based on principles so erroneous.

We may here ask the question: "Why should time vary with every mile of longitude?" The answer comes, It is not possible to conceive more than a single unity of time in the whole universe. Time, which is "an infinite continuity in infinite space," resembles a mighty river, whose unvarying stream passes before us. Such a river is unchangeable, yet continually changing; volumes of water always advancing are replaced by new volumes in perpetual succession, and yet the river continues one and the same ever flowing unity. The passing stream of time is much the same, and the problem presented to us is to keep a proper record of its flow. It is perfectly obvious that the principles which

should govern should be such as to secure complete accord in the detail of its admeasurement independently of locality. All peoples are concerned in the attainment of harmonious results, and therefore it is important that they should acquiesce in the employment of the same unit of computation and in counting the measurements from one common zero.

We have not to look in vain for a convenient unit and the most perfect instrument for measuring the passage of time. The rotation of the earth on its axis is marked by complete uniformity of movement, and nothing is more certain than the recurrence of this diurnal phenomenon. Accordingly the earth itself supplies all our wants as a time-keeper; in it we have at our command a perpetual standard for the use and guidance of the entire family of man.

Before, however, we can attain this end it is essential that mankind should come to an agreement on the following points:

1. With respect to a zero from which the revolutions are to be counted.
2. The acceptance of a common subdivision and a common notation by which parts of revolutions will be known by all and receive universal recognition.

The importance of a definite understanding on these points is self-evident, for if each individual or group of individuals adheres to the practice of observing time from different zeros and each maintains separate reckonings of it, the outcome must be general confusion, such as we now experience.

If in imagination we place ourselves at one extremity of the earth's axis, we shall find ourselves in a particularly favorable position, free from all local influences, for observing the revolutions of the globe. At no other point in the northern hemisphere are the conditions the same. A spectator standing at the north pole would have neither east nor west; in whatever direction he might cast his eyes he would look towards the south; he would no longer see the daily return of sunrise and sunset; the sun when visible would move, or seem to move, in a horizontal line, and its path would encircle the earth parallel to and not far distant from the horizon. Under such circumstances it would not be possible to note the diurnal revolutions of the earth by the rising or setting of the sun, or by the sun's greatest altitude at mid-day, or by his southern position in the heavens. As the passage of time can only be marked by events, what course could be followed? Obviously it would be necessary to take special means to observe the earth's diurnal rotation, and the method most readily to suggest itself would be to select a conspicuous object near the horizon and according to this object observe the sun's passage over it. The object so selected would become the zero of time, and the interval between two successive solar passages would be the period occupied by a revolution of the earth. If from zero the horizon be divided into a series of arcs of 15° each the whole circle around will consist of twenty-four divisions. If each of the division points be

numbered from zero in the direction contrary to the motion of the earth or towards the right, and in imagination the numbers be placed in a conspicuous manner against the sky, the spectator will have within his range of vision a great dial-plate on which as it revolves the vertical sun will continually point to the passing hours. With the twenty-four division points so numbered around the circle of the horizon, it is obvious that every hour in the day, and equally the smaller divisions of time, will invariably be manifested by the solar passage.

As the imaginary point of observation, the north pole, is common to every meridian, the hours and minutes indicated by the great polar chronometer will be equally common to every locality on the surface of the globe. Whatever the longitude, the solar passage will be the index of time. Two successive passages at zero will complete an interval of twenty-four hours; but it will not be a day in the ordinary sense, as an ordinary day is a local phenomenon in no two longitudes identical.* To distinguish this new interval of time common to the whole world from the infinite number of local days at present recognized it has been suggested to term it the "Cosmic Day," or some distinctive appellation by which it may be known.

Necessarily the zero point must be arbitrarily selected according to convenience, and any zero whatever, other things being equal, would serve the purpose which we have in view. We have only to assume the zero so selected to coincide with the Antiprime Meridian determined by the Washington Conference, and the Cosmic Day will be identical with the Universal Day, established under the same authority. A Universal or Cosmic Day may therefore be defined as the interval of time between two succeeding solar passages at the Antiprime Meridian common to all nations.

In his recent discourse on the subject at the Royal Institution, London, the astronomer royal for Great Britain, Mr. Christie, expressed a preference for the term "World Time" to designate this new measure of duration. It has been termed "Cosmic Time" by various societies and individuals; but the name is of secondary importance, if it be understood that the new measure of time is equally related to every locality. By its very nature, Cosmic Time, or by whatever name it may be known, must coincide with some one of the multiplicity of existing times. The decision of the Washington Conference caused it to correspond with Greenwich Civil Time. Greenwich time is the local time of Greenwich. Cosmic Time is a new and an entirely different conception; it is the time of the world common to every nation. "Cosmic" and "Greenwich" time are identical fortuitously, but the expressions imply two totally different ideas, and a proper deference to national sensitiveness suggests the good taste and expediency of distinguishing the two ideas by different terms. Some distinctive name is undoubtedly called for, until the

* The Nautical Almanac defines an ordinary solar day to be the interval of time between the departure of any meridian from the sun and its succeeding return to it.

period arrives when the unification of time will be complete. In the not far distant future it may become equally as unnecessary to speak of "Solar," "Lunar," "Astronomical," "Civil," "Nautical," "Local," "Cosmic," or "World" time, as at present it is unnecessary to attach these or other distinctive appellations to "Space." The simple expression "Time" may then become sufficient for all purposes.

1 Longitude east and west from Greenwich.	2 Longitude west from time zero.	3 Longitude by hour meridians.	4 Cosmic Time at mean solar passage.
0	*	Number.	Hour.
180 antiprime meridian ..	180	0	Change of the day.
165 east	15	1	1
150 east	30	2	2
135 east	45	3	3
120 east	60	4	4
105 east	75	5	5
90 east	90	6	6
75 east	105	7	7
60 east	120	8	8
45 east	135	9	9
30 east	150	10	10
15 east	165	11	11
0 the prime meridian ..	180	12	12
15 west	195	13	13
30 west	210	14	14
45 west	225	15	15
60 west	240	16	16
75 west	255	17	17
90 west	270	18	18
105 west	285	19	19
120 west	300	20	20
135 west	315	21	21
150 west	330	22	22
165 west	345	23	23
180 antiprime meridian ..	360 and 0	0 and 24	24 and change.

* Zero of Cosmic Time and of Longitude.

The relation between time and longitude is important. If longitude be reckoned by hour meridians, as in the second and third columns of the table, that is to say, numbered continually westward from the Anti-prime Meridian, which is the true time zero, the inhabitants of every individual locality in whatever longitude will daily have an opportunity of regulating time by the great natural standard of measurement. The longitude of the locality being known, at mean solar passage the time will invariably and precisely agree with the longitude. Conversely, the time being known, the longitude of the place will be in strict agreement with time at the moment of mean solar passage.

A reference to the following plate will make it clear that the solar passage will be the invariable index of Cosmic Time.

Fig. 1 shows the relative position of sun and earth at the initial instant of the Cosmic Day, that is, at the moment of mean solar passage on the Antiprime Meridian adopted by the Washington Conference.

Fig. 2 gives the position when the earth has made a sixth of a revolution and four hours have elapsed. The solar passage at this stage is on the four-hour meridian.

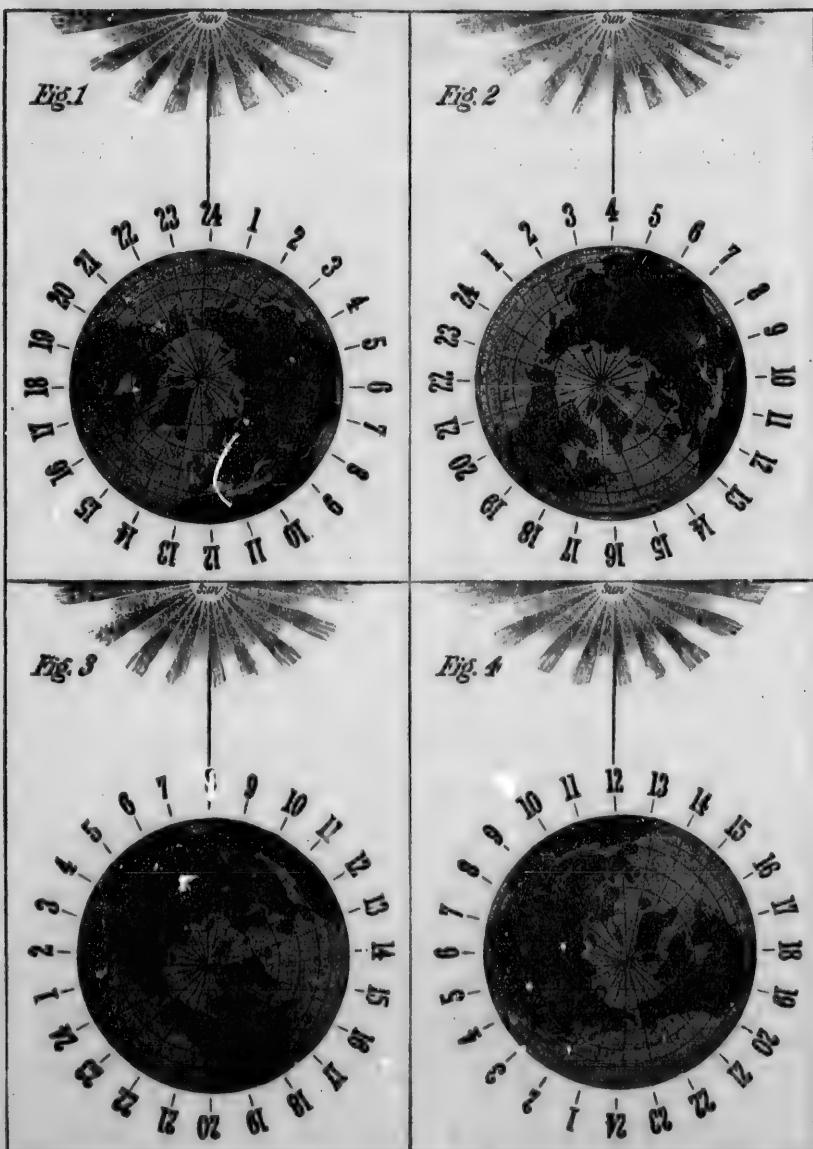
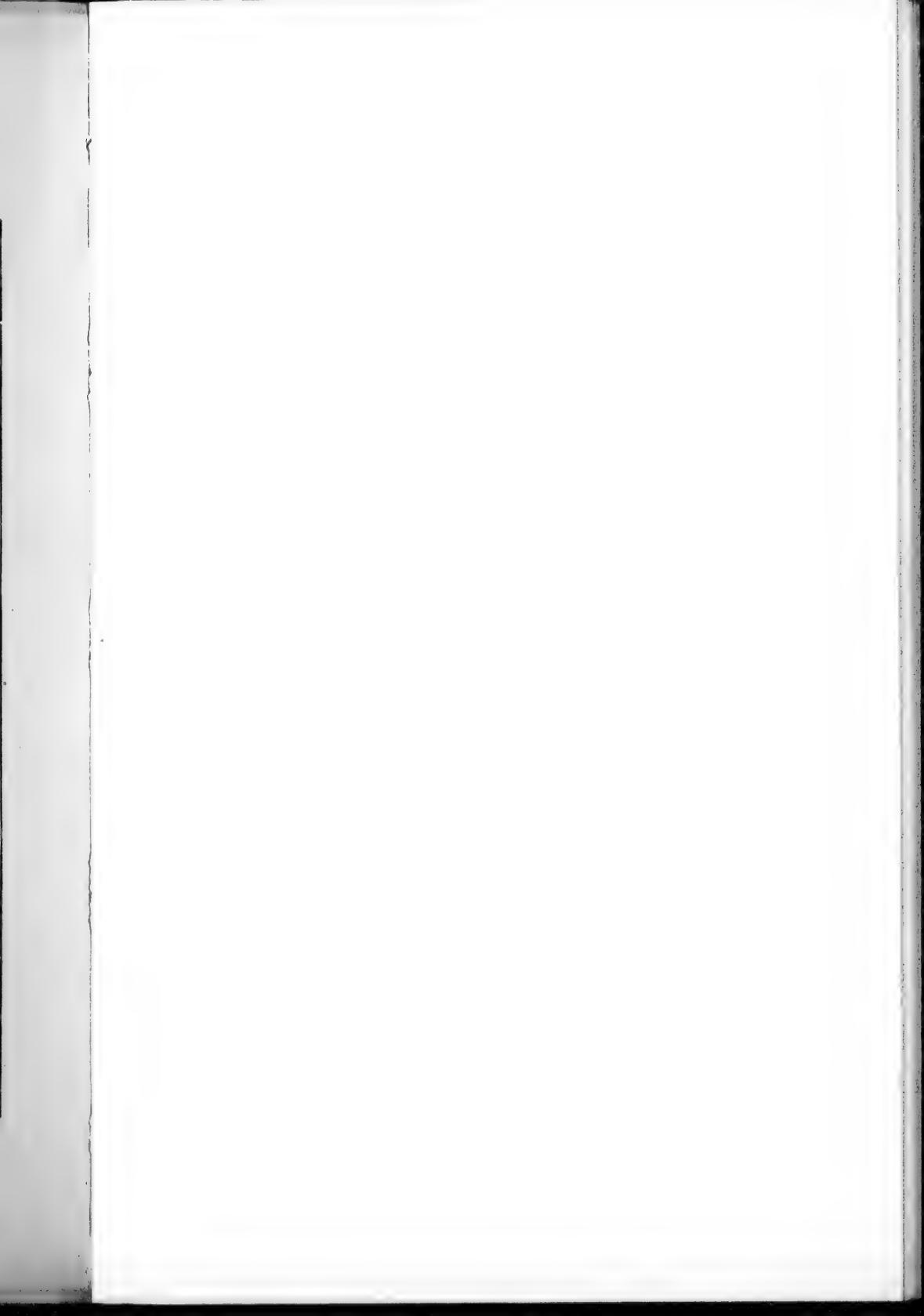


Fig. 3. When the earth has made a third of a revolution and occupied a period of eight hours, the solar passage occurs on the eight-hour meridian.



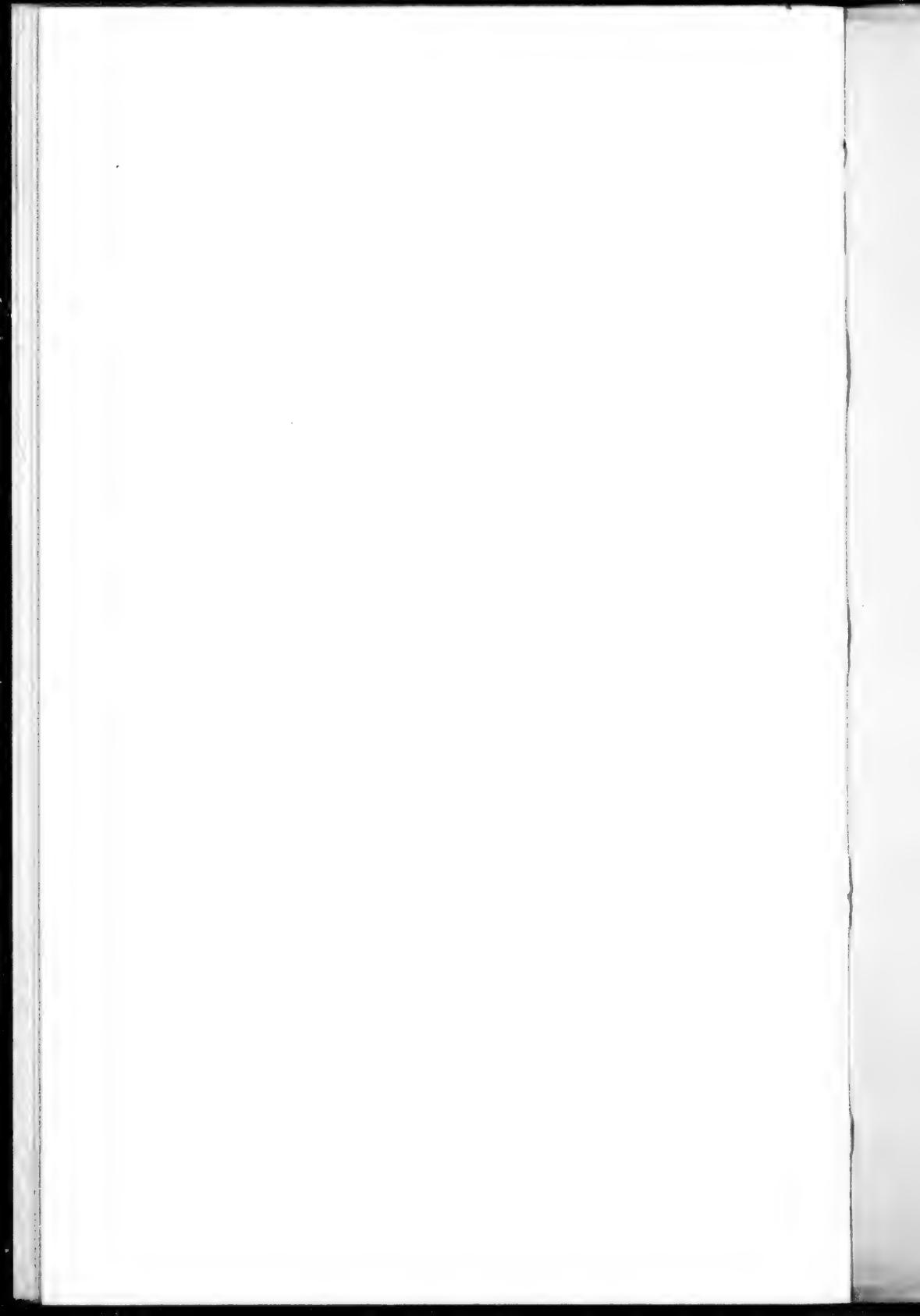


Fig. 4. When the earth has made half a revolution and twelve hours have elapsed, the solar passage is at this stage on twelve-hour or Prime Meridian.

Similarly for every other meridian, and thus the precise relation between Cosmic Time and longitude is definitely established.

It may be said that Cosmic or Universal Time is accepted in science, but its adoption in ordinary life can only be gradually and perhaps with difficulty effected. It is not to be looked for that a change so marked, involving a revolution of thought in some of our social customs, can be speedily introduced, however desirable it may be in the public interest. There is a class of men who habitually express their contempt for what they designate as "new-fangled notions," and who refuse to go out of sight of old landmarks. The usages which we desire to supersede are certainly old, for they took their origin when our civilization was young. In those days it was a dogma that the earth had a flat surface, but as the belief that the earth is a plane is no longer invested with the authority of a truth, we may venture to call in question the theory that each locality on its surface possesses an independent stream of time and is called upon to defend and maintain it. The human race is no longer confined within a narrow area. It has overspread the surface of the earth; in the Old and New Worlds it has grown, in some portions of their extent it is still growing, from an infantile condition to a state of manhood. Are we not yet able to look beyond one individual horizon and enlarge our range of vision so as to include a system which will satisfy the requirements, not of a locality, but of the whole globe?

We are living in an age of intellectual and social progress, when men are less fettered than our fathers were by the restraints of custom. On the continent of North America extraordinary progress has already been made by an essentially practical people towards the adoption of a complete reform in time-reckoning. What is known as the Standard-hour system, in itself in complete harmony with the principles of Cosmic Time, has been in common use for nearly three years, and it is generally recognized as an incalculable benefit to the whole community.

Throughout the United States and Canada we have outgrown the notion of isolating each locality by compelling it to observe a separate time notation. The Continent is divided into zones, each zone having the same time throughout its extent, based on a meridian which is a multiple of fifteen degrees from the Prime Meridian. Consequently the time of each zone varies exactly one hour from that of the adjoining zones. Thus all the variations of time which formerly were limited only by the number of towns and cities and localities which observed their own local time are reduced to the five zones. Only at points where the zones come in contact is there any exception to the common satisfaction which has resulted from the change. These are the only localities where we find the old-time difficulties, now so happily removed from every other section of the Continent. At such localities the difficulties must con-

tinue to be felt until Cosmic Time comes into general use, for it is the only one remedy which can satisfy every requirement.

The Standard-hour system is an effective preliminary means for the introduction of universal time, and it is not confined to North America. In Sweden, as well as Great Britain, the principle is in common use. The Standard Time of Sweden is based on the meridian fifteen degrees east of the prime meridian; consequently an hour in advance of the Prime Meridian time. The time of Great Britain is that of the prime meridian itself.

The scheme of hour meridians can only be regarded as a provisional arrangement. It greatly lessens the difficulties experienced, but it does not wholly remove them. It is, however, an important practical step towards the general unification of time, as it brings the minutes and seconds into complete agreement with the world's time wherever the system is adopted. The Astronomer Royal of Great Britain calls particular attention to the breadth of view evidenced by the managers of the American railways who were so largely instrumental in having this important step taken. "By adopting a national meridian as the basis of their time-system they might have rendered impracticable the idea of a universal time to be used by Europe as well as America. But they rose above national jealousies and decided to have their time-reckoning based on the meridian which was likely to suit the convenience of the greatest number, thus doing their utmost to promote uniformity of time throughout the world by setting an example of the sacrifice of human susceptibilities to general expediency."

There is one feature of time-reform alluded to by President Arthur in his message to Congress which promises before long to be accepted by the community. I refer to the proposal to count the hours from zero to twenty-four. The recent report of the special committee on Standard Time of the American Society of Civil Engineers (January, 1886) thus alludes to this branch of the subject:

"This feature has the authority of the International Conference for its introduction. In intelligent circles in Europe, particularly in England and in Russia, also at the antipodes in Australia, the proposal is reported to have been greeted with enthusiasm. The Astronomer Royal of England, Mr. Christie, has established at Greenwich Observatory a division of the great dial into twenty-four hours. In London and in other cities, public clocks have been also changed to accustom the English public to this division of the day. Some newspapers in all their announcements adopt the change, and scientific societies give notice of the meetings in the same manner as this Society, according to the twenty-four-hour system.

"On this Continent there has been no uncertain sound. In the last annual report of the Committee it was stated that one hundred and seventy-one managers of railways in the United States and Canada had declared their readiness to abandon the division of the day into half-days,

known as *ante* and *post* meridian, and to accept the numeration of the hours in one series, from midnight to midnight, these managers having under their control some 60,000 miles of railway.

"During the past year the seed sown has been fructifying, and many who held back have been won over and have given their adhesion to the movement. Among the many important railways ready to co-operate, some appear to see no necessity for further delay, and desire to secure at once the advantages which will result from the change. At this date it is publicly announced that the Canadian Pacific Railway Company have determined to adopt the 24-hour system, and are actually preparing to make the change at an early day.* Such proceedings can be accepted as indicating a proper appreciation of the reform which the American Society of Civil Engineers has advocated, and equally shows the discernment of those who direct the management of the youngest of the transcontinental railways. This practical commencement will, without a doubt, be speedily followed by other railway companies, and before long we may look for the 24-hour system coming into general use.†

There is undoubtedly a growing feeling in many quarters in favor of the 24-hour system. It is reported to be used with great advantage on the whole of the cables and other lines of the Eastern Telegraph Company, and its connections extending from England through Europe and the Mediterranean to Egypt, and from Egypt to South Africa, India, China, and Japan, Australia, and New Zealand.

It is a pertinent question to ask, what influence these various changes will have in preparing the public mind for another, and it may be said a final, change—the adoption of one uniform time in every longitude! For it must be evident to the thoughtful observer that the movement

* At midsummer, 1886, the Canadian Pacific Railway was opened from the Atlantic to the Pacific and the 24-hour system went into force in running "through" trains. The example set by the railway company has been followed in the towns and villages along the line, and the inhabitants generally having experienced the advantages of the change, no desire is expressed in any quarter to return to the old usage.

†The following foot-note is added: "It is proposed to adapt clocks and watches now in use to the change, by having inscribed on the existing dials the new numbers of the afternoon hours—thirteen to twenty-four (13 to 24) inclusive. The only practical difficulty to be overcome is met by the simple expedient of placing on the face of the watch or clock a supplementary dial, showing the new afternoon hours in Arabic numerals within the present Roman figures. The supplementary dial must be of thin material, and it has been found that, by being made simply of paper and secured to its position by any gum which will adhere to an enamelled surface, the object is attained without any further alteration of the watch or clock. The committee is aware that these seem trifling matters to bring under the notice of the convention, but questions of great moment not seldom hinge on small details. It is evident, from what has been set forth, that every person in the community may, at the cost of a few cents in each case, adapt his watch to the 24-hour system. The committee accordingly repeat their conviction that, with the disappearance of the only practical difficulty at an insignificant cost, there is nothing to prevent the railway authorities and the community at large adopting the change as soon as they become alive to its advantages."—Report of the Buffalo Convention of the American Society of Civil Engineers.

for reforming our time-system will not have attained its object until this end be accomplished.

Those persons who have been in the habit of finishing their daily work at 6 p. m. under the 24-hour system will end it at 18. Those who retired to rest at 10 or 11 p. m. will seek their beds at 22 or 23. The idea that solar noon and 12 o'clock are one and inseparable has already been set aside throughout the United States and Canada; only on five meridians—the 60th, 75th, 90th, 105th, and 120th—is it held to be 12 o'clock at the mean solar passage. In all other longitudes throughout North America the identity between solar noon and 12 o'clock has practically been swept away.

These modifications in the time reckoning must tend to remove the idea that there is some necessary connection between the numbers of the hours and the position of the sun in each local firmament. The force of habit has heretofore associated noon with 12 o'clock, but in due time it will become obvious to every one that the hour of the sun's passage at any one locality may with as much propriety be distinguished by any one of the twenty-four numbers as by the now generally received number 12. So soon as this new idea comes generally to be accepted, so soon as it is understood that the numbers of the hours are arbitrary and conventional, it will not be difficult to take the final step in time reform and entirely supersede the present system by a notation which will give to mankind throughout the world simultaneous dates and hours and minutes.

The final step may appear to involve serious changes in much which concerns every individual, but it is not to be supposed that it will in any way interfere with the periods for labor, sleep, meals, or any ordinary usage. The one change will be in the numbers of the hours. In social affairs the regulating influence of daylight and darkness will always, as now, be paramount. The terms "noon" and "midnight" will continue to preserve their present meaning, although the numbers of the hours at which these periods occur will vary in each case according to longitude. Each separate meridian will have its own midnight hour distinguished from the midnight hours of other meridians by a distinctive number. So also with the noon hour, which, as already stated, will invariably agree with the longitude of the place. It is the midnight hour in each locality which will constitute the initial time-point to regulate the legal hours for opening and closing banks, registry, and other public offices. The midnight hour may be arbitrarily chosen and be established by statute as circumstances may demand. It will be held to be the local zero to govern the hours of business, working hours, the hours for attendance at church, at school, and at places of amusement, and generally to regulate all the social affairs of life. While the seven week days will practically remain unchanged in every longitude, the simple expedient of numbering the hours so that everywhere they will correspond with Cosmic Time will result in securing the general uniformity to be desired. Thus it will be obvious that in all matters

relating to time, whether local or non-local, the same hours, minutes, and seconds will universally be observed at the same instant. In cases where business men separated by long distances make contracts by telegraph, the engagements will be free from all ambiguity as to time. Both parties will be bound absolutely by the same notation.

The Cosmic Day is a new measure of time entirely non-local. It will be held to be the date of the world, and the change of date will occur at the same instant in all longitudes. On the prime meridian the change of date will be at midnight; to the east it will occur after midnight; and to the west of the prime meridian it will come before midnight. It will be one hour before or after midnight for every fifteen degrees of west or east longitude. Fortunately, in nearly all the important countries on the surface of the globe, the change of date will occur out of ordinary business hours.

It will thus be seen that while the contemplated reform will interfere as little as possible with existing customs, it will result in giving to the human family around the globe concurrent dates and in making every division of time uniform the world over.

In the adoption of the new system, temporary inconvenience may arise, but it will be trifling in extent and not of long duration; and any momentary disadvantage should not be allowed to weigh against the benefits to be secured to mankind for all future ages.

On the night of November 18, 1883, a noiseless revolution was effected throughout the United States and Canada. The hands of the clocks of some fifty millions of people were for the most part moved forward or backward in order to indicate the time of one of the five hour zones. The time now observed from the Atlantic coast to the Pacific varies with Cosmic Time, according to situation, from four to eight whole hours. In North America, therefore, the portion of the problem yet to be adjusted is easy of solution. As the minutes and seconds are already everywhere in agreement, the transition to universal uniformity of reckoning can be effected simply and with ease. It will only be necessary to move forward the dial hands of the clocks an even number of hours, varying from four to eight, as each case may require, to bring the Continent into complete accord with the time of the world.

When eventually it may become necessary to bring the time throughout all parts of North America to the world's standard, the transition may be effected by adjusting the clocks as follows:

I. Clocks in the hour zones of the west meridians.

Meridian west.	Hours.
60°	4
75°	5
90°	6
105°	7
120°	8

will have to be moved *forward*

Similarly wherever the scheme of hour meridians be adopted the common reckoning may with equal ease be secured. To the west of the

prime meridian the clocks will require to be moved forward, to the east backward. In Europe, Asia, and Africa the change would thus be effected:

II. *Clocks in the hour zones of the east meridians.*

Meridian east.	Hours.
15°	1
30°	2
45°	3
60°	4
75°	5
90°	6

Thus, for example, New Orleans, in the hour zone of the 90th meridian west, would have its clocks advanced six hours, while Calcutta, in the 90th meridian east, would have its clocks retarded six hours. By the same simple process of transition, every city and district on the surface of the globe may be brought to the one common time-reckoning.

It is a significant fact that at the Washington Conference the principle of Universal Time obtained unanimous recognition from the delegates of so many nationalities. It is a presage that the peoples whom they represent will before long be fully impressed with the belief that a system of reckoning time uniformly throughout the globe is really the one rational system by which it can be noted, and the only system which will meet the demands of the human family in coming years. It is only step by step that a reform so great can be carried out. Moreover, although the difficulties to be overcome are undoubtedly serious, this much may be said with confidence, that they are less formidable than those which have already been conquered. A few years back the very question of a universal time for all nations was a theory not only new in itself but it was held by many to be wild and Utopian, and so impracticable as to be unworthy of consideration. In 1873 the subject could not command a hearing at the British Association! Since 1878 the arguments advanced to point out the necessity of change have, however, obtained attention, and a general movement for reform has been inaugurated. Scientific and practical men and learned societies in both hemispheres have taken part in the consideration of the question. It has formed the subject of discussion at International Congresses at Venice and Rome. The President and Congress of the United States have been induced to take decisive action in connection with it. The governments of twenty-five civilized nations have aided in its development. The International Washington Conference itself has greatly promoted the solution of the problem by coming to an unanimous determination on the essential principles to be observed. In several countries the recommendations of the conference have already in part been acted on, and changes have been effected which a few years back were not even dreamed of.

If so much has been accomplished within the eight years since the scheme of reform was first promulgated, is it too much to expect that the public mind will be prepared in the more advanced communities to accept the final step in a like period?

In about a dozen years we pass into another century. Is it taking too sanguine a view to suggest that by that time all nations will be willing to accept the change, and that the first day of January in the Twentieth Century may appropriately be inaugurated by the adoption of one uniform system of reckoning time throughout the world?

I learn from the recent lecture of the Astronomer Royal that the Board of Visitors of Greenwich Observatory have unanimously recommended that, in accordance with the resolutions of the Washington Conference, the Astronomical day should in the English Nautical Almanac be arranged from the year 1891 (the earliest practicable date) to begin at Greenwich midnight, so as to agree with the civil reckoning, and further that steps have been taken to give effect to this recommendation; thus in a few years this source of confusion to sailors navigating ships using the Nautical Almanac—embracing at least 70 per cent. of the tonnage of the world—will be removed. The distinguished Russian Astronomer, Struve, has suggested that all astronomers throughout the world should simultaneously abandon Astronomical Time and bring their notation into harmony with the civil reckoning. He further suggests that this reform should be introduced into the publications of observatories at the initial day of the century. In reference to this the Astronomer Royal, Greenwich, says (October, 1885) "it would be intolerable to have a fundamental question of time-reckoning left open for fifteen years," and urges that the step be taken ten years earlier. Be that as it may with regard to the assimilation of the astronomical and civil notations no one can question that the change of the century is an appropriate period for effecting the complete unification of time, and doing away with all the errors of our present mode of reckoning. Every auxiliary circumstance points to the possibility of that result being attained. The proceedings of the Washington Conference have given the movement an immense impulse. Its members have authoritatively recognized the principles on which the new notation may be established. So unimpeachable and simple are these principles as to be within the grasp of the most limited comprehension. In their application we may have to contend against the prejudices engendered by habit and custom, but the principles of reckoning time adopted by the conference are based on truth and they commend themselves to every one of intelligence, as the proper means to meet the admitted emergency. The unanimity with which the standard hour system was brought into common use in North America is an evidence that the age is sufficiently intelligent to adopt a reform when its advantages are understood. It will doubtless require the lapse of some years to win over those who feel it to be a bounden duty to cling to old institutions and existing customs. Grad-

nally, however, the minds of the great mass of men will become familiarized with the new ideas and in the end the new system of notation can not fail to prevail. The main obstacles to be overcome are the restraints which tradition imposes and the usages which our ancestors have transmitted to us. But prejudices of this character can be gradually and certainly surmounted, if the true principles of time-reckoning be taught in schools and colleges. In a few years the youth of to-day will be moving actors in life, to influence public opinion and so effect an easy escape from the thralldom of custom. We have therefore good grounds for the belief that, by the dawn of the coming century, the civilized nations may enjoy a system of notation limited to no locality; when the record of the events of history will be unmarked by doubt; when ambiguity in hours and dates will be at an end; when every division of time will be concurrent in all longitudes.

These expectations realized, the Washington Conference will have rendered a great service to mankind. If the reforms of B. C. 46 and A. D. 1582 owed their origin to the dominant necessity of removing confusion in connection with the notations which existed in the then conditions of the human race, in no less degree is another reform demanded by the new conditions which are presented in this age. Obviously the needed change could not be consummated at a more suitable period than at the beginning of the new century, but whether effected at that or an earlier date, a provision is made for the change in the conclusions and recommendations of the Washington Conference—a conference which, representing all civilized nations and having established the fundamental principles of the new notation, must be held by future generations to mark an epoch in the annals of the world not less important than those of the reforms of Julius Caesar and Pope Gregory XIII.

SUPPLEMENTARY NOTE.

TIME RECKONING FROM THE PROCEEDINGS OF THE CANADIAN INSTITUTE 1878-'79.

(*Extract.*)

Persons who inhabit different sections of the earth differ from each other in their reckoning of the day. At one place it is noon, at another it is midnight; at a third it is sunrise, at a fourth it is sunset. In consequence we have the elements of confusion, which involve in some cases the mistake of a whole day.

People even living in the same meridian may differ a day in their usual reckoning of time, according as the countries they inhabit have been colonized from the one side or the other of the globe. There are instances in the Pacific Ocean where islands almost adjacent reckon by different days of the month and week; a circumstance calculated to produce much confusion when intercourse becomes frequent.

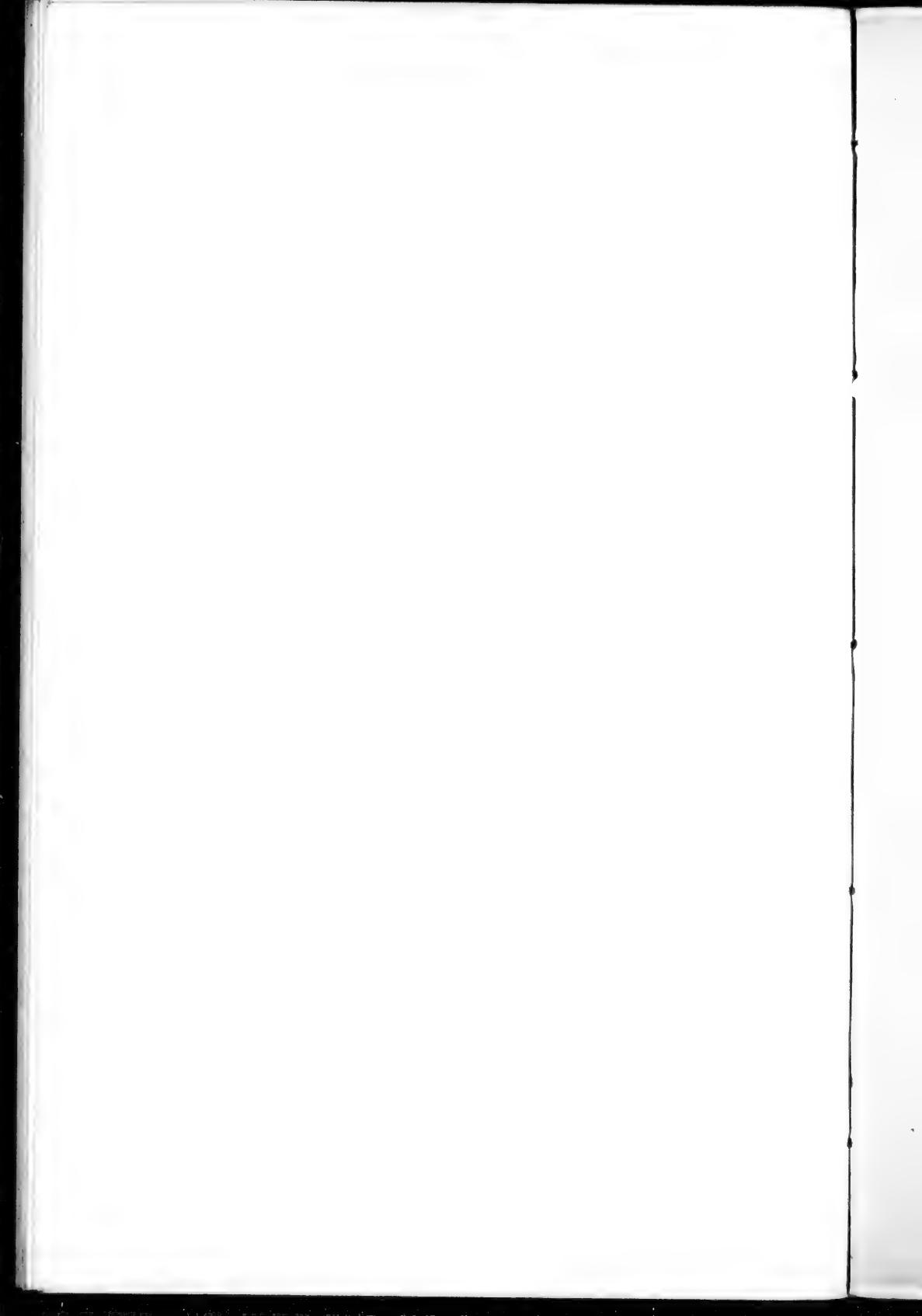
In Alaska the days of the week and month were one day in advance of those in the adjacent colony of British Columbia, indeed of the whole of America. On the advent of citizens of the United States a few years ago, when that territory was transferred by Russia, the Saturday was found to be the Sunday of the old residents. For ordinary business purposes a change became necessary, and a dispensation was granted in 1871 by the dignitaries of the Greek Church in Russia, authorizing their

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missionaries and adherents in Alaska to celebrate Sunday a day later, or on Monday, according to the old reckoning.

The reverse has been met in another quarter of the globe. The Philippine Islands, lying between Australia and Asia, and about 100 degrees of longitude to the west of Alaska, were discovered in 1521 by the illustrious Magellan in his memorable first circumnavigation of the globe. That navigator followed the sun in his path around the world. Legaspi succeeded him and took possession of these important islands in the name of Philip II, King of Spain. The Philippine Islands extend for a thousand miles from north to south, they embrace Manilla, one of the oldest cities of the Indies, and they contain a population of 5,000,000. They were colonized, as well as discovered, by Spaniards coming from the East, and as a consequence the reckoning of the inhabitants has for more than three centuries remained a day behind the day in British India and the neighboring countries in Asia.

Travelers who arrive at New Zealand or the Australian colonies by the San Francisco route meet the same difference, owing to the fact that the countries in the South Pacific were colonized from the West. The day of the week and of the month carried from San Francisco never agrees with the day and date reckoned by the inhabitants at the destination of the steamer.

All travelers who have made the voyage between America and Asia have experienced the difficulty in reckoning referred to. Those who have proceeded westward have lost, while those who have traveled eastward have gained a day. In Mrs. Brassey's *Around the World in the Yacht Sunbeam*, this experience is recorded. The journal of that lady passes from Wednesday, January 10, directly to Friday, January 12—Thursday, January 11, having no existence with the travelers.

In sailing across the Pacific from west to east, one day has to be repeated before landing on the American coast. If, for example, the correction be made on Wednesday, 1st July, there will be two Wednesdays in the one week, and two days of the month dated July 1.

A journey round the world is now an everyday undertaking, and is accomplished with comparative ease. Suppose two travelers set out from a given place, one going eastwardly, the other westwardly. A singular circumstance will result when they both return to the common starting point, and the reason is obvious. One man will arrive, according to his reckoning, say on Tuesday, December 31, when in fact at that locality it is Wednesday, Janu^r 1. The other traveler, assuming that he has kept accurately a daily journal, will enter in his diary on precisely the same day, Thursday, January 2. This consequence has been brought out by Edgar Allan Poe, in his amusing story of "Three Sundays in one Week," but it no longer can be held to be an imaginary contingency, since steam communication by land and water is now affording extraordinary facilities for making the tour of the globe.

To illustrate the difficulty more particularly. First, let us select points in four quarters of the globe, each about 90 degrees apart, say in Japan, Arabia, Newfoundland, and Alaska. If we assume it to be Sunday midnight at the first-mentioned place, it must be noon at the opposite point, Newfoundland, but on what day is it noon? Arabia being to the west of Japan, the local time there will be 6 p. m., on Sunday, and Alaska, lying to the east of Japan, the time there will be 6 a. m. on Monday. Again, when the clock indicates 6 p. m. on Sunday in Arabia, it must be Sunday noon at a point 90 degrees farther west, or at Newfoundland; when it is 6 a. m. on Monday in Alaska, it must be noon on Monday 90 degrees farther east, also at Newfoundland. Thus, by tracing local time east and west from a given point to its antipodes, the clock on the one hand becomes twelve hours slower, on the other hand twelve hours faster. In the case in point, while it is midnight on Sunday in Japan, at precisely the same moment it is noon at Newfoundland on two distinct days, viz., on Sunday and on Monday.

Secondly, let us trace local time only in one direction around the earth. The day does not begin everywhere at the same moment. Its commencement travels from

east to west with the sun, as the earth revolves in the opposite direction, and it takes an entire revolution of the globe on its axis for the day everywhere to be entered on. Immediately on the completion of one revolution the inception of any one day ends, and at this moment the end of the day begins; and the globe must make another complete revolution before the end of the day entirely finishes. The globe must in fact make two entire revolutions before any one week day runs out, consequently each and every day of the week runs over forty-eight hours; and, taking the whole globe into account, two civil days always co-exist. The first twenty-four hours of one day co-exist with the last twenty-four hours of its predecessor, while the remaining twenty-four hours co-exist with the first twenty-four hours of the day which follows.

It is difficult to accept the fact that any one day lasts more than twenty-four hours; but it can be demonstrated that it is the case. Let us place together several maps of the world on Mercator's "Projection," so as to represent, in consecutive order, each part of the earth's surface as it passes the sun during several diurnal revolutions. (See plate).

$A^1 A^2$, $A^3 A^4$, are intended to represent each a complete map of the world. Within each of these limits every place on the earth's surface is brought under the sun during a daily revolution.

The vertical lines $E I N R V$ represent meridians, for the sake of simplicity selected 60 degrees apart, and the stars or dots at their intersection denote the beginning and end of a day on each of the six meridians. As the earth revolves, the sun passes successively the meridians of those localities, with an interval of four hours elapsing between each.

Let us assume it to be 12 o'clock midnight on Thursday at meridian A . At that moment and at that place Friday begins and runs for twenty-four hours, or on the diagram from A to A^1 .

Four hours later Friday begins on meridian E , and runs four hours on the second map, or into the second revolution of the earth. Four hours still later Friday begins on meridian I and runs eight on the second map or into the second revolution. This goes on from spot to spot, until at last the commencement of Friday reaches the last meridian, and at that point Friday runs entirely across the second map to A^2 . Thus Friday begins at A , runs during two complete revolutions of the earth, as shown on the map from A to A^2 .

The diagram will thus illustrate the duration of every day in the week, and it becomes obvious, when we take a general view of the whole globe on any given day, say Saturday, that day begins in the middle of Friday and does not end until the middle of Sunday. Friday, on the other hand, beginning in the middle of Thursday, runs into the middle of Saturday, while Sunday commences at the moment Friday ends. To state the case differently: the same moment of absolute time which is part of Saturday in one place, is equally part of Friday and of Sunday in some other places east and west.

It is a preconceived idea with many that there is a simultaneous Sunday over the earth, and that Christians in every meridian keep the Lord's day at one and the same time. Facts, however, establish that this is a mistake. From its first commencement to its final ending, the Sunday extends over forty-eight hours. Indeed, if we take into account the remarkable circumstance mentioned with regard to Alaska and the Philippine Islands, Sunday has been discovered to run over some fifty-five hours. The same may be said of any day in the week; and as a consequence we have, taking the whole globe into view, Saturday and Monday running over the intervening Sunday to overlap each other about seven hours. We have, in fact as a constant occurrence, portions of three consecutive days co-existent.

From the fact that not only are the hours of the day different in every meridian, but that different days are constantly in progress on the face of the globe, it is a difficult matter under our present system of reckoning to assign relatively the hour and

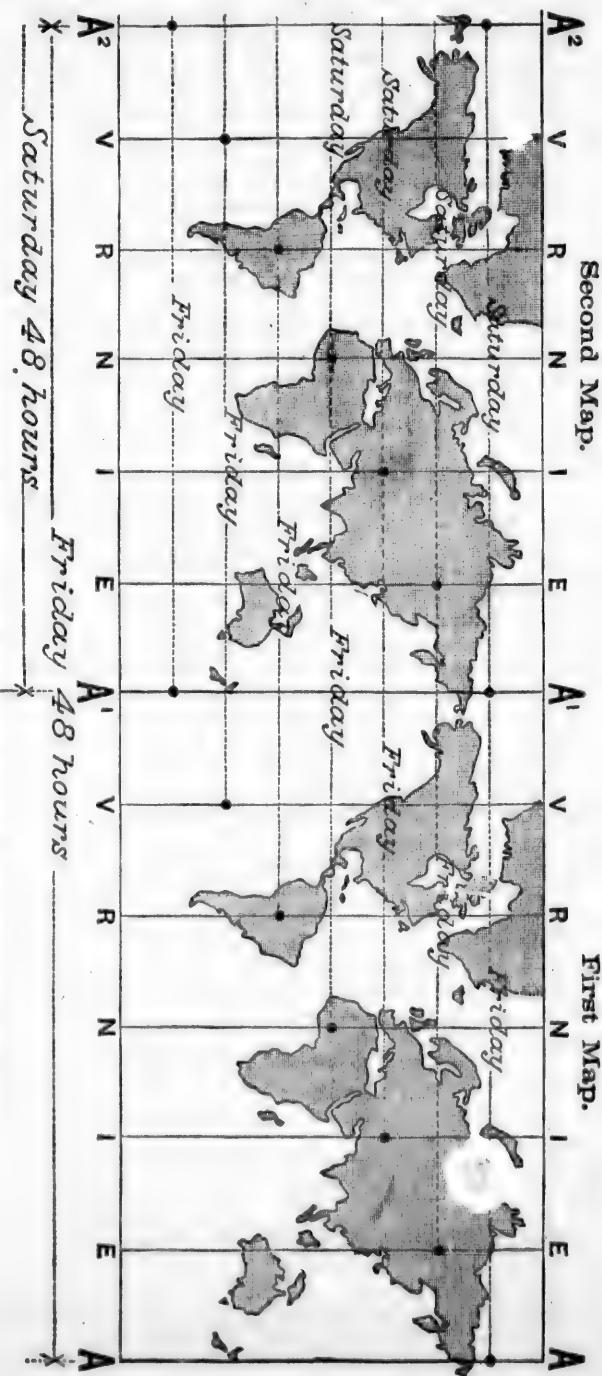


Diagram to illustrate the progress and duration of the days of the week around the globe.

day when events take place. We may learn of an occurrence, and the time assigned will be correct in the meridian of the locality. Everywhere else it will be inaccurate. Indeed, if the fact of the occurrence be transmitted over the world by telegraph, it may, in some places, be recorded on different days.* If the incident occurs at the close of a year, or a year, it may actually take place in two different months, or two distinct years.

Under our present system it is quite possible for two events to take place several hours apart, the first and older occurring in the new year in one locality; the second, although the more recent in absolute time, falling, in another locality, within the old year. The same may be said of events that occur during the period which elapses when one century merges into another. In one part of the globe the same event may transpire in the nineteenth century, while in another it falls within the twentieth century.

Another difficulty, forced on the attention by the science of the century, is mainly due to the agency of electricity, employed as a means of telegraphy, and to steam applied to locomotives. These extraordinary sister agencies having revolutionized the relation of distance and time, having bridged space, and drawn into closer affinity portions of the earth's surface previously separated by long and, in some cases, inaccessible distances.

Let us take the case of a traveler in North America. He lands at Halifax in Nova Scotia, and starts by a railway to Chicago through the eastern portions of Canada. His route is over the Intercolonial, the Grand Trunk, and other lines. He stops at St. John, Quebec, Montreal, Ottawa, Toronto, Hamilton, and Detroit. At the beginning of the journey he sets his watch by Halifax time. As he reaches each place in succession, he finds a considerable variation in the clocks by which the trains are run, and he discovers that at no two places is the same time used. Between Halifax and Chicago he finds the railways observing no less than seven different standards of time. If the traveller remains at any one of the cities referred to, he must alter his watch to avoid inconvenience, and perhaps not a few disappointments and annoyances to himself and others. If, however, he should not alter his watch, he would discover on reaching Chicago that it was an hour and thirty-five minutes faster than the clocks and watches in that city.

If his journey be made by one of the routes through the United States, the variation in time and its inconveniences will not be less. If he extends his journey west of Chicago, traveling from place to place until he reaches San Francisco, he will meet continual change, and finally discovers a loss in time of nearly four hours (3h. 56m.). Between the extreme points there are many standards of time, each city or place of importance generally being governed by its own meridian. Hence the discrepancies which perplex the traveler in moving from place to place.

On the continent of Europe, and indeed wherever lines of communication extend between points differing to any considerable extent in longitude, the same difficulty is experienced. On a journey from Paris to Vienna or to St. Petersburg, the standard time employed by the railways changes frequently, and the extreme difference in time between the first and last city is nearly two hours. As railways and telegraphs are extended in Russia, the inconveniences will become of serious importance in that country. Within the limits of Russia in Europe and Asia, the extreme variations of time is about twelve hours.

Suppose we take the case of a person traveling from London to India. He starts with Greenwich time, but he scarcely leaves the shores of England when he finds his watch no longer right. Paris time is used for the journey until that of Rome becomes the standard. At Brindisi there is another change. Up the Mediterranean ships' time is used. At Alexandria Egyptian time is the standard. At Suez, ships'

* TIME AND THE TELEGRAPH.—A message dated Simla, 1.55 a. m. Wednesday, was received in London at 11.47 p. m. on Tuesday. As the clerk said, with pardonable confusion, "Why, this message was sent off to-morrow."—Times.

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time is resumed, and continues, with daily changes, until India is reached. Arriving at Bombay, the traveler will find two standards employed, local time and railway time, the latter being that of Madras. If he has not altered his watch since he left England, he will find it some five hours slow. Should he continue his journey to China, it will have fallen eight hours behind.

In the United Kingdom the difficulties due to longitude are only felt in a modified form. The greater island, embracing England and Scotland, is comparatively limited in width; one standard of time is therefore used. It is only in respect to the sister island, Ireland, that the difference in longitude calls for a difference in time. In the whole United Kingdom, consequently, there are practically only two standards, viz., Greenwich time and Irish time, the difference being twenty-five minutes. No one, therefore, whose experience has been confined to the United Kingdom, can form an adequate idea of the extent of the inconvenience arising from the causes alluded to, where geographical circumstances render necessary the use of a multiplicity of standards.

The railway system is the principal agent in the developing of the difficulties referred to, and the still further extension of steam communications in great continental lines is forcing the subject on public attention. Canada supplies a good illustration of what is occurring. The railways built and projected will extend from the eastern coast of Newfoundland on the Atlantic to the western coast of British Columbia on the Pacific, embracing about 75° of longitude. Every Canadian city has its own time. Innumerable settlements are now being formed throughout the country ultimately to be traversed by railways; and in a few years scores of populous towns and cities will spring up in the now uninhabited territories between the two oceans. Each of these places will have its own local time, and the difference between the clocks at the two extremes of Canada will be fully $4\frac{1}{2}$ hours. The difficulties which will ultimately arise from this state of things are apparent. They are already in some degree felt, they are year by year increasing, and will at no distant day become seriously inconvenient. This is the case not in Canada alone, but all the world over.

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The division of the day into two halves, each containing twelve hours, and each numbered from 1 to 12, is also a fertile source of error and inconvenience.

Travelers who have had occasion to consult railway guides and steam-boat timetables will be familiar with the inconvenience resulting from this cause; none know better by experience how much the divisions *ante meridian* and *post meridian* have baffled their inquiries, and how often these arbitrary divisions have led to mistakes. Were it necessary, innumerable instances could be given. The evil, however, is one so familiar that it has come to be looked upon as unavoidable, and is, as a matter of course, silently endured.

The halving of the day has doubtless long been in use, but beyond its claim to antiquity, is a custom that confers not a single benefit, and is marked by nothing to recommend it.

SCHEME OF COSMIC OR UNIVERSAL TIME.

1. That a system of universal time be established, with the view of facilitating synchronous scientific observations, for chronological reckonings, for the purpose of trade and commerce by sea and land, and for all such uses to which it is applicable.
2. That the system be established for the common observance of all peoples, and of such a character that it may be adopted by each separate community, as may be found expedient.
3. That the system be based on the principle that for all terrestrial time-reckonings there be one recognized unit of measurement only, and that all measured intervals of time be directly related to the one-unit measure.
4. That the unit measure be the period occupied by the diurnal revolution of the earth, defined by the mean solar passage at the meridian twelve hours from the prime meridian established through Greenwich.

5. That the unit measure defined as above be held to be a day absolute, and designated a cosmic day.

6. That such cosmic day be held as the chronological date of the earth, changing with the mean solar passage at the anti-meridian of Greenwich.

7. That all divisions and multiples of the cosmic day be known as cosmic time.

8. That the cosmic day be divided into hours, numbered in a single series, one to twenty-four (1 to 24), and that the hours be subdivided, as ordinary hours, into minutes and seconds.

NOTE.—As an alternative means of distinguishing the cosmic hours from the hours in local reckonings, they may be denoted by the letters of the alphabet, which, omitting I and V, are twenty-four in number.

9. That until cosmic time be accepted as the recognized means of reckoning in the ordinary affairs of life, it is advisable to assimilate the system to present usages, and to provide for the easy translation of local reckonings into cosmic time, and *vice versa*; that, therefore, in theory, and as closely as possible in practice, local reckonings be based on a known interval in advance or behind cosmic time.

10. That the surface of the globe be divided by twenty-four equi-distant hour-meridians, corresponding with the hours of the cosmic day.

11. That, as far as practicable, the several hour-meridians be taken according to the longitude of the locality, to regulate local reckonings, in a manner similar to the system in use throughout North America.

12. That in all cases where an hour-meridian is adopted as the standard for regulating local reckonings in a particular section or district, the civil day shall be held to commence twelve hours before, and end twelve hours after, the mean solar passage of such hour meridian.

13. That the civil day, based on the prime meridian of Greenwich, shall coincide and be one with the cosmic day. That civil days on meridians east of Greenwich shall be (according to the longitude) a known number of hours, or hours and minutes, in advance of cosmic time, and to the west of Greenwich the contrary.

14. That the surface of the globe being divided by twenty-four equi-distant meridians (fifteen degrees apart) corresponding with the hours of the cosmic day, it is advisable that longitude be reckoned according to these hour-meridians.

15. That divisions of longitude less than an hour (fifteen degrees) be reckoned in minutes and seconds and parts of seconds.

16. That longitude be reckoned continuously towards the west, beginning with zero at the anti-prime meridian, twelve hours from Greenwich.

17. That longitude generally be denoted by the same terms as those applied to cosmic time.

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